SCIENTIFIC DIGITAL JOURNAL

FRONTIERS OF BIOSCIENCE

ISSN # 3085-9069 Dec, 2025 ISSUE N. 18



Neuroendocrine and Microbiome Dimensions of GLP-1 Receptor Agonism in Obesity Management

Scientific Digital Journal
frontiersofbioscience@gon1.com.br

https://doi.org/10.6084/m9.figshare.31444741

DR. DEIVIS O. GUIMARÃES
DR. THULIO R.G. DE ALMEIDA

The present article broadly and critically examines the role of glucagon like peptide 1 receptor agonists in the contemporary management of obesity, articulating pathophysiological, molecular, clinical, microbiological, economic, and ethical dimensions. Obesity is presented not merely as excessive accumulation of adipose tissue, but as a complex chronic condition marked by neuroendocrine dysfunction, leptin resistance, low grade systemic inflammation, and significant alterations in the composition and functionality of the intestinal microbiota. The text explores in depth the biology of GLP 1, describing its intracellular signaling pathways, its systemic distribution, and its integration with the gut brain axis, highlighting the multifactorial and pleiotropic nature of its metabolic effects.

The major clinical trials that support the therapeutic adoption of this pharmacological class are critically analyzed, including the STEP, SURMOUNT, LEADER, and SUSTAIN programs, with emphasis on methodological robustness and the temporal limitations of the available studies. Clinical response heterogeneity, the need for continuous therapeutic maintenance, and the phenomenon of weight regain following treatment discontinuation are discussed. The manuscript also explores metabolic consequences associated with prolonged use, such as loss of lean mass, adaptation of energy expenditure, and possible modifications of the hypothalamic set point.

The analysis further extends to the potential impact of sustained caloric suppression on intestinal ecology, addressing the production of short chain fatty acids, epithelial barrier integrity, and bidirectional interactions between the microbiota and incretin signaling. Finally, the article examines the expansion of use beyond formal clinical indications, discussing the phenomenon of aesthetic medicalization, the economic influence in the expansion of therapeutic markets, and the implications for public and private health systems. It concludes that although GLP 1 receptor agonists represent a significant therapeutic advance, their broad incorporation requires rigorous longitudinal monitoring, continuous critical evaluation, and regulatory prudence.

1. Obesity as a Complex Neuroendocrine and Metabolic Disease

Reducing obesity to mere excess adipose tissue constitutes an inadequate simplification in light of current knowledge. It is a multifactorial chronic condition involving dysregulation of hypothalamic signaling, peripheral insulin resistance, complex hormonal alterations, and persistent low grade systemic inflammation. Epidemiological data from the World Health Organization indicate a progressive increase in global prevalence, configuring a scenario of growing public health relevance.

From a pathophysiological standpoint, alterations in the arcuate nucleus of the hypothalamus stand out, a region responsible for integrating peripheral signals of satiety and hunger. Leptin resistance compromises anorexigenic signaling efficacy, while changes in ghrelin secretion modulate orexigenic impulses. Morton et al., 2014, demonstrated that progressive desensitization of hypothalamic insulin and leptin pathways contributes to the maintenance of positive energy balance in chronic obesity.

In parallel, modifications in the intestinal microbiota emerge as a relevant component of this pathophysiology. Reduced bacterial diversity and alterations in the proportion between Firmicutes and Bacteroidetes, described by Turnbaugh et al., 2006, are associated with greater

efficiency in dietary energy extraction and activation of systemic inflammatory pathways. This interface between microbiota, metabolism, and inflammation reinforces the integrative nature of the disease.

Within this context, effective therapeutic interventions must operate at multiple levels of the metabolic network, justifying the growing interest in pharmacological agents capable of simultaneously modulating central satiety, hormonal secretion, and gastrointestinal dynamics.

2. GLP-1 Physiology and Systemic Integration with Energy Control

Understanding the therapeutic relevance of GLP-1 receptor agonists requires detailed analysis of endogenous GLP-1 biology and its strategic role in energy homeostasis regulation. GLP-1 derives from proglucagon cleavage in enteroendocrine L cells, predominantly located in the distal ileum and proximal colon. Its secretion occurs in response to food intake and is stimulated by nutrients and metabolites produced by the intestinal microbiota, especially short chain fatty acids.

Drucker, 2018, describes that the GLP-1 receptor belongs to the class B family of G protein coupled receptors, with expression distributed across multiple tissues, including pancreatic beta cells, hypothalamic neurons, the nucleus tractus solitarius, myocardium, and vascular endothelium. This broad anatomical distribution explains the pleiotropic spectrum of metabolic and cardiovascular effects observed in clinical practice.

Receptor activation triggers increased cyclic AMP, activation of protein kinase A, and modulation of transcription factors such as CREB. In pancreatic beta cells, this cascade promotes glucose dependent insulin secretion, reducing the risk of hypoglycemia compared to traditional secretagogues. However, limiting GLP-1 action to the pancreatic axis would be incomplete, as its central influence on hypothalamic satiety circuits constitutes a crucial component of its clinical effect.

Furthermore, GLP-1 integrates a functional circuit connecting intestine, microbiota, vagus nerve, and brain, composing a highly sophisticated axis of adaptation to the nutritional environment. Pharmacological intervention in this system implies prolonged modification of an evolutionarily shaped mechanism designed to respond to fluctuations in food availability.

3. Clinical Evidence: Methodological, Robustness, Limitations, and Critical Interpretation

Clinical trials that consolidated GLP-1 receptor agonists as first line therapy for obesity present rigorous methodological design, including randomization, double blinding, and placebo control. The STEP program, led by Wilding et al., 2021, included nearly two thousand participants and demonstrated an average weight reduction of 14.9 percent over 68 weeks. The SURMOUNT program, conducted by Jastreboff et al., 2022, demonstrated reductions exceeding 20 percent with tirzepatide.

From a statistical standpoint, these results are extraordinary. However, clinical interpretation requires analysis beyond arithmetic mean values. Response heterogeneity is relevant. A significant fraction of participants exhibited modest responses, whereas another portion achieved reductions greater than 20 percent. This variability suggests genetic, epigenetic, microbiomic, and behavioral influences that remain insufficiently understood.

Another frequently underestimated point is the necessity for continuous therapy maintenance. The STEP 4 study demonstrated that treatment interruption resulted in recovery of approximately two thirds of the weight lost within one year. This raises a central question: are we facing an indefinite chronic therapy? If so, what are the metabolic consequences of artificial incretin modulation over decades?

Moreover, most clinical trials have follow up limited to 68 or 72 weeks. Obesity, however, is a decades long condition. Extrapolation of one and a half year data to lifelong use must be approached with scientific caution.

4. Indiscriminate Use: Between Clinical Evidence and Cultural Expansion of Prescription

International guidelines establish objective criteria for prescribing GLP-1 receptor agonists, generally based on body mass index equal to or greater than 30 kilograms per square meter, or equal to or greater than 27 in the presence of metabolic comorbidities. These criteria reflect a carefully weighted risk benefit assessment in populations with increased cardiometabolic risk. However, a progressive displacement of these boundaries has been observed in daily practice.

Use in individuals with mild overweight, or even within what is considered the normal range, has been reported in various contexts. Such expansion does not result solely from individual demand but also from a cultural environment that values rapid weight reduction and from indirect commercial communication strategies.

Kesselheim et al., 2016, demonstrated that pharmaceutical promotional materials can influence physicians' clinical perception, expanding therapeutic scope beyond strict indications.

From an ethical standpoint, the central issue is not to deny drug efficacy, but to evaluate proportionality. In patients with grade 3 obesity associated with diabetes and elevated cardiovascular risk, the benefit is unequivocal. In metabolically healthy individuals with borderline BMI and predominantly aesthetic motivation, the balance between clinical benefit and prolonged pharmacological exposure becomes more delicate.

There is also a sociocultural dimension. The medicalization of weight control may reduce emphasis on structural interventions such as food policy reform, nutritional education, and promotion of physical activity. The availability of an effective pharmacological solution does not eliminate the need for a systemic approach to obesity as an environmental, behavioral, and social phenomenon.

5. Metabolic Consequences of Prolonged Chronic Use

The continuous action of GLP-1 receptor agonists persistently modifies a hormonal axis that, under physiological conditions, operates episodically and in response to food intake. Endogenous GLP-1 has a half life of only a few minutes and is rapidly degraded by dipeptidyl peptidase 4. The use of long acting analogues administered weekly replaces this transient dynamic with sustained signaling.

Prolonged reduction of caloric intake triggers classic adaptive responses described by Rosenbaum and Leibel, 2010, including reduction of resting energy expenditure and increased muscular metabolic efficiency. These mechanisms represent evolutionary responses to sustained weight loss and may contribute to the tendency for weight regain following therapy discontinuation.

Body composition analyses reveal that a relevant portion of weight loss involves lean mass. Jiang et al., 2021, documented significant reduction of fat free mass in participants treated with semaglutide. Skeletal muscle plays a central role in peripheral glucose uptake and basal energy metabolism. Its reduction may impair insulin sensitivity and facilitate metabolic adaptation favoring weight regain.

At the neuroendocrine level, it remains unclear whether durable redefinition of the hypothalamic set point occurs or whether therapy functions predominantly as a transient suppressive modulator. Animal models suggest that prolonged exposure to hormonal alterations may induce synaptic remodeling and epigenetic modifications.

However, longitudinal human investigations remain limited.

However, longitudinal human investigations remain limited.

Interaction with other appetite regulating hormones also warrants attention. Ghrelin, the primary orexigenic hormone, tends to increase after weight loss. The magnitude of this increase following discontinuation of GLP-1 agonists may contribute to compensatory hyperphagia, reinforcing treatment chronicity.

6. Intestinal Microbiota Under Pharmacologically Induced Chronic Caloric Suppression

The intestinal microbiota constitutes a dynamic ecosystem strongly influenced by dietary patterns. Sustained caloric reduction induced by GLP-1 agonists inevitably alters the availability of fermentable substrates. This may impact production of short chain fatty acids such as butyrate, propionate, and acetate, metabolites involved in epithelial barrier integrity and immunometabolic modulation.

Turnbaugh et al., 2006, demonstrated that obesity associated microbiota exhibits greater capacity for energy harvest. Cani et al., 2007, showed that alterations in intestinal permeability may contribute to metabolic endotoxemia and low grade systemic inflammation. The unresolved question is whether pharmacologically induced weight loss stably reverses this microbial profile or produces a new ecological configuration whose long term stability remains uncertain.

Preliminary studies suggest increased Akkermansia muciniphila during weight loss, a microorganism associated with mucosal layer integrity. However, evidence remains limited by small sample size and short follow up duration.

Bidirectional interaction between microbiota and incretin signaling adds further complexity. Bacterial metabolites stimulate endogenous GLP-1 secretion. Structural alterations in microbiota may therefore modify basal incretin physiology, establishing feedback circuits not yet sufficiently explored in long term clinical trials.

7. Gut Brain Axis, Neuroinflammation, and Metabolic Set Point Regulation

The gut brain axis represents an integrated functional network involving neural, immunological, endocrine, and metabolic pathways. Bidirectional communication occurs through the vagus nerve, systemic circulation of bacterial metabolites, inflammatory cytokines, and intestinal hormones including GLP-1 itself. Cryan et al., 2019, demonstrated that alterations in microbiota composition can modulate feeding behavior, stress reactivity, and reward processing. Therefore, any sustained modification in dietary pattern inevitably reverberates throughout this network.

Obesity is associated with chronic low grade hypothalamic inflammation characterized by microglial activation and resistance to leptin and insulin signaling. Weight loss, whether achieved through bariatric surgery or pharmacological intervention, may reduce central inflammatory markers. However, it remains unclear whether continuous incretin stimulation exerts direct effects on hypothalamic inflammatory pathways or whether observed benefits are secondary solely to reduction in visceral adiposity.

The metabolic set point hypothesis proposes that the organism defends a predetermined body weight through integrated homeostatic mechanisms. Bariatric surgery appears to modify this set point more durably, possibly due to permanent anatomical changes and profound postprandial hormonal alterations. In the case of GLP-1 receptor agonists, the pattern of weight regain following discontinuation suggests that the original set point may remain biologically active in most individuals.

From a neurobiological perspective, prolonged stimulation of POMC neurons and inhibition of NPY AgRP neurons within the arcuate nucleus may induce compensatory adaptations. Animal studies indicate that chronic hormonal exposure can result in epigenetic modifications and synaptic remodeling. Translation of these findings to humans still lacks robust longitudinal evidence.

There is also interaction with peripheral neurotransmitters such as intestinal serotonin, whose synthesis depends on tryptophan availability and microbial activity. Sustained alterations in food intake may influence peripheral serotonin production, affecting gastrointestinal motility and vagal afferent signaling. The clinical impact of this modulation remains insufficiently explored.

8. Pharmaceutical Innovation Economics and Market Expansion

The commercial trajectory of GLP-1 receptor agonists illustrates how therapeutic innovation can redefine global markets. Initially positioned as antidiabetic agents with additional cardiovascular benefits, these drugs assumed a central role in obesity treatment following publication of results demonstrating historically unprecedented magnitudes of weight reduction for pharmacological interventions.

Public financial reports indicate exponential revenue growth associated with semaglutide and tirzepatide, with market projections reaching tens of billions of dollars annually. This economic expansion is not explained solely by the increasing prevalence of obesity, but also by the progressive enlargement of the population eligible for treatment.

Health economics literature demonstrates that gradual redefinitions of diagnostic criteria and expansion of therapeutic indications may occur alongside the commercial success of a pharmacological class. Kesselheim et al., 2016, discuss how promotional materials can influence clinical perception and broaden prescribing scope.

From a systemic perspective, it is essential to distinguish legitimate innovation from expanded medicalization of cultural standards. Severe obesity, associated with high cardiovascular risk, constitutes a disease with significant impact on morbidity and mortality. However, when use extends to metabolically healthy individuals with predominantly aesthetic motivation, the risk benefit analysis assumes different contours.

Another relevant aspect concerns economic sustainability. Cost effectiveness studies such as Whittington et al., 2022, suggest that cost per quality adjusted life year may be acceptable in high cardiometabolic risk populations. However, extrapolation to large scale use, especially within public health systems, requires long term economic modeling that considers indefinite chronic treatment.

9. Population Level Metabolic Consequences and Long Term Hypotheses

Widespread and prolonged use of GLP-1 agonists at population scale raises questions that extend beyond individual efficacy observed in clinical trials. The history of pharmacology demonstrates that rare or cumulative effects may emerge only after exposure of millions of individuals over many years.

From a physiological perspective, replacement of endogenous pulsatile secretion with continuous signaling may induce receptor adaptations. In other hormonal systems, such as the thyroid or gonadal axes, prolonged stimulation can result in desensitization or altered gene expression. There are still no conclusive data regarding the impact of use exceeding ten years on GLP-1 receptor dynamics.

The adaptive thermogenesis described by Rosenbaum and Leibel, 2010, suggests that persistent body weight reduction is accompanied by decreased basal energy expenditure beyond what would be predicted from loss of body mass alone. At a population level, this could create a scenario in which therapeutic interruption systematically results in weight regain, reinforcing chronic medication dependence.

In the microbiota domain, prolonged exposure to reduced caloric intake may remodel the

intestinal ecosystem in ways not yet fully understood. Alterations in short chain fatty acid production and bacterial composition may influence systemic immunomodulation, hepatic metabolism, and epithelial barrier integrity.

The hypothesis that combinatory interventions including structured resistance training and nutritional strategies aimed at preserving lean mass and microbial diversity may mitigate some of these adaptations represents a promising field of investigation.

10. Medical Responsibility and Clinical Ethics

The adoption of innovative therapies requires balance between scientific enthusiasm and ethical prudence. The principle of proportionality implies that pharmacological exposure should be compatible with the severity and risk of the treated condition. In grade 3 obesity associated with diabetes and cardiovascular disease, clinical benefit is substantial. In individuals with borderline BMI and low metabolic risk, analysis becomes more complex.

Therapeutic decisions must integrate individualized risk assessment, metabolic profile, and prior structured attempts at non pharmacological interventions. Premature introduction of chronic pharmacotherapy without adequate behavioral intervention may displace a more integrative approach to obesity management.

Transparency regarding knowledge gaps is an essential component of ethical practice. The absence of long term follow up data must be explicitly communicated to patients. Evidence based medicine includes not only positive trial outcomes but also recognition of remaining uncertainties.

Furthermore, the relationship between the pharmaceutical industry and biomedical research, although fundamental to innovation, requires ongoing vigilance to mitigate conflicts of interest and preserve scientific independence.

11. Future Perspectives: Scientific Gaps, Structural Monitoring, and Translational Integration

The advance represented by GLP-1 receptor agonists does not conclude scientific debate but inaugurates a new phase of physiological and translational investigation. The magnitude of weight loss observed in phase III trials redefines therapeutic expectations, yet simultaneously increases the responsibility of the scientific community to understand the biological consequences of sustained incretin modulation over years or decades. Obesity is a chronic condition with prolonged course, and interventions intended for its control must be evaluated within a time horizon compatible with that clinical reality.

One of the most evident gaps lies in the absence of studies with follow up beyond five or ten years evaluating continuous GLP-1 agonist use in large populations. Human physiology operates through complex adaptive mechanisms, and persistent pharmacological stimulation of a G protein coupled receptor with systemic distribution may induce progressive alterations in gene expression, receptor mediated sensitivity, and central synaptic architecture. Longitudinal assessment of potential desensitization phenomena, transcriptional modulation, or neural remodeling requires specific protocols integrating functional neuroimaging, molecular biomarkers, and detailed behavioral evaluation.

Body composition should constitute a central axis of future research. Weight loss alone does not fully capture the metabolic impact of an intervention. It is imperative to evaluate lean mass, bone mineral density, mitochondrial muscle function, and physical performance parameters over time. Preservation of muscular compartment is determinant for maintaining peripheral insulin sensitivity and preventing excessive thermogenic adaptation. Studies combining incretin therapy with structured resistance training programs may clarify whether it is possible to mitigate lean mass loss observed in portions of clinical trials.

In the field of intestinal microbiota, the need for in depth investigation is equally evident. Sustained modulation of food intake alters availability of fermentable substrates and consequently the production of bacterial metabolites such as butyrate, propionate, and acetate. Longitudinal protocols including metagenomic analysis, fecal metabolomics, and assessment of epithelial barrier integrity are essential to determine whether therapy induced microbial remodeling is stable, beneficial, or potentially deleterious in the long term. The interaction between microbiota and endogenous GLP-1 secretion also represents a promising field capable of revealing compensatory mechanisms not yet described.

Moreover, integrated multiomics approaches may clarify whether chronic incretin modulation promotes persistent epigenetic alterations in metabolic tissues including hypothalamus, liver, skeletal muscle, and adipose tissue. Incorporation of transcriptomics, proteomics, and systemic metabolomics in long term cohorts will allow mapping of molecular adaptations not captured by conventional clinical endpoints.

Finally, clinical guidelines and public health policies must remain dynamic, adapting as new data emerge. Scientific prudence does not constitute an obstacle to progress, but rather a necessary condition for its sustainability. The consolidation of this therapeutic class as a central tool in obesity management will depend on the collective capacity to integrate innovation, rigorous monitoring, and continuous critical evaluation.

Conclusion

GLP-1 receptor agonists represent one of the most relevant pharmacological innovations in the treatment of obesity and type 2 diabetes in recent decades. By acting on a central axis of energy homeostasis, these agents promote substantial reduction in caloric intake, improvement in glycemic control, and cardiovascular benefits documented in high risk populations. The available clinical evidence demonstrates robust efficacy and an acceptable safety profile in the short and medium term, justifying their incorporation into international guidelines.

However, sustained pharmacological intervention upon a physiological system evolutionarily shaped to operate in pulsatile fashion raises legitimate questions regarding long term neuroendocrine adaptations. Continuous incretin signaling modifies hypothalamic satiety circuits, interacts with the gut brain axis, and alters systemic metabolic dynamics. Concomitant loss of lean mass, adaptive reduction in energy expenditure, and the phenomenon of weight regain following discontinuation suggest that, in many cases, therapy functions as a suppressive modulator of body weight without necessarily permanently redefining the metabolic set point.

The microbiological dimension adds further complexity. The intestinal microbiota constitutes a functional component of metabolic regulation, and sustained dietary alterations induced by GLP-1 agonists may remodel this ecosystem in ways not yet fully understood. The bidirectional interaction between bacterial metabolites and incretin secretion reinforces the need for integrated investigation.

On the socioeconomic plane, expansion of use beyond formal indications imposes ethical and regulatory reflection. In individuals with severe obesity and high cardiometabolic risk, clinical benefit is unequivocal. In metabolically healthy populations, risk benefit analysis must be conducted with proportional caution. The economic sustainability of high cost chronic therapies also represents a relevant variable for health systems.

In summary, GLP-1 receptor agonists inaugurate a new paradigm in obesity pharmacotherapy, combining significant efficacy with sophisticated physiological mechanisms. However, definitive consolidation of this strategy will depend on generation of independent longitudinal evidence, integration with behavioral and nutritional approaches that preserve lean mass and microbial diversity, and maintenance of scientific prudence in the face of uncertainties inherent to chronic modulation of complex hormonal systems.

References

1. World Health Organization. Obesity and overweight. Geneva: WHO; 2023.
2. Morton GJ, Meek TH, Schwartz MW. Neurobiology of food intake in health and disease. Nat Rev Neurosci. 2014;15(6):367–378.
3. Rosenbaum M, Leibel RL. Adaptive thermogenesis in humans. Int J Obes. 2010;34 Suppl 1:S47–S55.
4. Turnbaugh PJ, Ley RE, Mahowald MA, Magrini V, Mardis ER, Gordon JI. An obesity-associated gut microbiome with increased capacity for energy harvest. Nature. 2006;444(7122):1027–1031.
5. Cani PD, Amar J, Iglesias MA, Poggi M, Knauf C, Bastelica D, et al. Metabolic endotoxemia initiates obesity and insulin resistance. Diabetes. 2007;56(7):1761–1772.
6. Cani PD, Lecourt E, Dewulf EM, Sohet FM, Pachikian BD, Naslain D, et al. Gut microbiota fermentation of dietary fiber increases GLP-1 production. Diabetes. 2009;58(6):1470–1478.
7. Drucker DJ. Mechanisms of Action and Therapeutic Application of Glucagon-like Peptide-1. Cell Metab. 2018;27(4):740–756.
8. Holst JJ. The physiology of glucagon-like peptide 1. Physiol Rev. 2007;87(4):1409–1439.
9. Secher A, Jelsing J, Baquero AF, Hecksher-Sørensen J, Cowley MA, Dalbøge LS, et al. The arcuate nucleus mediates GLP-1 receptor agonist liraglutide-dependent weight loss. J Clin Invest. 2014;124(10):4473–4488.
10. Dickson SL, Shirazi RH, Hansson C, Bergquist F, Nissbrandt H, Skibicka KP. The glucagon-like peptide 1 analogue liraglutide suppresses food intake via central mechanisms. J Neurosci. 2012;32(32):11184–11193.
11. Wilding JPH, Batterham RL, Calanna S, Davies M, Van Gaal LF, Lingvay I, et al. Once-weekly semaglutide in adults with overweight or obesity. N Engl J Med. 2021;384:989–1002.
12. Jastreboff AM, Aronne LJ, Ahmad NN, Wharton S, Connery L, Alves B, et al. Tirzepatide once weekly for the treatment of obesity. N Engl J Med. 2022;387:205–216.
13. Pi-Sunyer X, Astrup A, Fujioka K, Greenway F, Halpern A, Krempf M, et al. A randomized controlled trial of liraglutide for weight management. N Engl J Med. 2015;373:11–22.
14. Marso SP, Daniels GH, Brown-Frandsen K, Kristensen P, Mann JFE, Nauck MA, et al. Liraglutide and cardiovascular outcomes in type 2 diabetes. N Engl J Med. 2016;375:311–322.
15. Marso SP, Bain SC, Consoli A, Eliaschewitz FG, Jódar E, Leiter LA, et al. Semaglutide and cardiovascular outcomes in type 2 diabetes. N Engl J Med. 2016;375:1834–1844.
16. Cryan JF, O'Riordan KJ, Cowan CSM, Sandhu KV, Bastiaanssen TFS, Boehme M, et al. The microbiota–gut–brain axis. Physiol Rev. 2019;99(4):1877–2013.
17. Jiang Y, O'Neil PM, Kushner RF, Wilding JPH, et al. Body composition changes with semaglutide in obesity trials. Diabetes Obes Metab. 2021;23(1):155–163.
18. Monami M, Dicembrini I, Mannucci E. Pancreatitis and incretin-based therapies: a meta-analysis. Diabetes Obes Metab. 2014;16(1):48–56.
19. Whittington MD, McQueen RB, Ollendorf DA, Kumar VM, Chapman RH, Tice JA, et al. Cost-effectiveness of semaglutide 2.4 mg for chronic weight management. JAMA Health Forum. 2022;3(5):e220775.
20. Kesselheim AS, Robertson CT, Myers JA, Rose SL, Gillet V, Ross KM, et al. A randomized study of how physicians interpret drug promotional materials. J Gen Intern Med. 2016;31(8):882–888.

